Based upon a review of the information available to the working group, it appears that there is relatively little current or anticipated use by other services (other than RAS and ARNS) in the United States and elsewhere in the 1610-1626.5 portion of the L-band, and therefore no serious or sharing concerns are presented by the proposed allocations. The Commission's existing rules on primary and secondary allocations as the well as the new procedures established at WARC-92 for international notification and coordination of these primary and secondary MSS transmissions should be sufficient to protect adequately other services from harmful interference. Accordingly, no new rules or operating criteria are recommended for the protection of such services.

3.2 Current Use of the 1610-1626.5 MHz Band

Current use of this portion of the L-band by services other than RAS and ARNS is quite sparse in the United States and abroad. There is virtually no existing domestic use of the band by fixed, mobile, RDSS and other services. There are a limited number of countries that have allocated fixed services by footnote to the international allocation tables.

3.2.1 Domestic Allocations and Known Users

The band is allocated on a co-primary basis in the United States for RDSS (Earth-to-space). With the demise of the Geostar Corporation, there are no known plans for extensive RDSS usage of the band.[1] There are no fixed or mobile service allocations in this band, and a search of the latest FCC database indicated that no such systems are currently licensed to operate there.

3.2.2 International Allocations and Known Systems

RDSS is a co-primary service in Region 2 and in some countries in Regions 1 and 3. The only known system licensed in another country was Locstar which also is no longer in business. There are no known plans for any other international RDSS systems and none have been advanced published by the IFRB.

Eighteen countries have allocated fixed services on a primary basis in the bands 1550-1645.5 MHz and 1646.5-1660.5 MHz by footnote to the international allocation tables.[2] An additional 29 countries have allocated fixed services in the band 1540-1645.5 MHz and 1645.5-1660 MHz on a secondary basis.[3] There are no international mobile service allocation in the band. A search of the ITU International Frequency List revealed only one system registered in the 1616-1626.5 MHz band. This system is registered to Czechoslovakia. The IWG2 was not able to obtain complete information about foreign systems that might be operating in the fixed service in this band.

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[1]The FCC recently granted a special temporary authority (STA) to Newcomb Communications to operate the interim RDSS satellite packages left unused by Geostar when it was liquidated. That company has also applied for more permanent authority to operate these facilities. In its application, however, the applicant represented that it would only operate these satellite packages until such time as the proposed MSS systems became operational.

[2]ITU Fn 730 lists the following countries: Federal Republic of Germany, Austria, Bulgaria, Cameroon, Guinea, Hungary, Indonesia, Libya, Mali, Mongolia, Nigeria, Poland, the German Democratic Republic, Romania, Senegal, Czechoslovakia, France and the U.S.S.R.

[3]ITU Fn 727 lists the following countries: Afghanistan, Saudi Arabia, Bahrain, Bangladesh, the Congo, Egypt, the United Arab Emirates, Ethiopia, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Malta, Morocco, Niger, Oman, Pakistan, Qatar, Syria, Somalia, Sudan, Sri Lanka, Chad, Thailand, Togo, Yemen (P.D.R. of) and Zambia.

A radar system operating in Sweden currently occupies the 1590-1626.5 MHz band. This system is the only known system operating under ITU FN 731 which allocates this band to the aeronautical radio navigation service on a primary basis.

4.0 Sharing Issues between MSS in the 2483.5-2500 MHz Band and Other Services

4.1 Introduction

MSS will share the 2483.5-2500 MHz band with terrestrial fixed and mobile services. Some of these situations will require coordination. In addition, there are a number of miscellaneous services that share the 2483.5-2500 Mhz band with MSS and could occasionally cause interference to MSS if MSS receivers were very close to the offending transmitters. In particular there are some French radars in the radio locating service (RLS) and there are the electronic news gathering transmitters (ENG) in the broadcast auxiliary service (BAS) but these are few, sparsely located, and operate intermittently. Local area networks (LAN) using radio also use this band except in the U.S. where they are restricted to frequencies below 2483.5 MHz. Because of the low powers involved it is unlikely that these services will cause significant interference except in rare circumstances. The same is true of out of band emissions from ARABSAT and INSAT in the broadcast satellite service (BSS).

Two other services raise somewhat larger concerns. They are the MMDS/ITFS service, where out of band emissions from the lower channels could be troublesome, and the industrial, scientific, and microwave service (ISM), especially microwave ovens because there are so many of them.

4.2 Sharing with the Fixed and Mobile Services

Domestic and international frequency assignments for stations in the Fixed Service are provided in IWG2-63 and IWG2-15, respectively. It should be noted that international assignments generally do not reflect the full extent of frequency band usage. In the column for domestic licenses, assignments recorded at 2500 MHz are specially noted insofar as the band-edge operation of the associated stations may yield lower potential to cause or suffer interference.

4.2.1 Interference to Mobile Earth Stations from Fixed Transmitters

According to the FCC database, there are 737 licensed fixed stations in the 2483.5-2500 MHz band. Some of the transmitters may cause interference to mobile earth stations. In some cases, multiple transmitters may operate under the same link attribution. As of the mid-1980s, the FCC Rules for terrestrial services prohibit any increase in the number of licensed terrestrial transmitters. Most prevalent domestic terrestrial services indicated have the following general assignment parameters:

<u>Industrial, Petroleum</u>

FCC Rule Part: 94

EIRP:

18.8 dBW minimum (EMELF data base)

30 dBW median

45.0 dBW maximum (EMELF and authorized Part 94)

Bandwidth = 800 kHz typical (max. authorized per Part 94)

Antenna Gain = 24 to 35.8 dBi (often not given in EMELF)

Polarization = linear vertical and/or horizontal

Antenna Height = 6 to 80 meters

Broadcast Auxiliary

FCC Rule Part: 74

Antenna Input Power (part 74 limits):

- Fixed 20 Watts/channel

- Mobile, 12 Watts/channel

No analyses were provided to quantify the sharing constraints needed to prevent interference to mobile earth stations from domestic terrestrial facilities in the 2483.5-2500 MHz band. The practicality of moving these terrestrial facilities in other bands was not assessed.

Based on assignments in the International Frequency List and the coordination distances specified in Resolution 46 for mobile earth stations operating in the 2483.5-2500 MHz band (i.e., 500 km and 1000 km for ground-based and airborne mobile earth stations), coordination will be needed to determine the potential levels of interference from foreign stations operating in the Fixed Service. For mobile earth station operation in or over the U.S., coordination will be needed with Canada, Mexico, and Russia. For operation of mobile earth stations outside the U.S., operator coordination will be needed with Argentina, Austria, Belgium, Canada, Chile, Peoples Republic of China, Germany, Spain, France, Netherlands, Iran, Kuwait, Mexico, Malta, Czech and Slovak Federal Republics, Russia, Turkey, and Yugoslavia, as well as other administrations that may seek to notify fixed service assignments in the 2483.5-2500 MHz band.

4.2.2 Interference from MSS/RDSS Constellations to Fixed Systems

The Power Flux Density (PFD) generated by MSS/RDSS spacecraft, in excess of levels prescribed by RR 2566, may result in interfering signals at the receiver input of stations in the Fixed Service. The likelihood that these interference levels exceed acceptable levels may be different for geostationary and non-geostationary satellite networks. This interference mechanism is system specific (for both FS and MSS) and can best be addressed during coordination. (To eliminate the need to coordinate with other administrations, it is advisable that the MSS/RDSS spacecraft transmission not exceed the international PFD limit.)

4.3 Sharing Between MSS/RDSS and the Radio Location Service in the 2483.5-2500 MHz Band

IWG3 summarizes the available frequency assignment information for radio location systems that are operating or capable of operating in the 2483.5-2500 MHz band. The radio location service is domestically allocated in this band only for government use on a non-interfering basis (footnote US 41), and so interference from U.S. radio location systems is not an issue.

4.4 Interference to Mobile Earth Stations from Radio Location Transmitters

No analyses were provided to quantify the sharing constraints needed for protection of mobile earth stations from foreign radio location transmitters. Based on assignments in the International Frequency List and the coordination distances for mobile earth stations operating in the 2483.5-2500 MHz band, operator coordination will be needed to determine the potential levels of interference from foreign stations operating in the radiolocation service and to seek protection from those stations. The 500 km and 1000 km coordination distances in Resolution 46 pertain. For protection of mobile earth station operations in or over the U.S. and abroad, coordination will be needed with Canada and France. (St. Pierre & Miquelon)

4.5 Interference from MSS/RDSS Satellite to Radiolocation Receivers

No analyses of the potential interference from MSS/RDSS satellites to radiolocation receivers were provided. However, it is possible that the PFD constraints needed to protect the fixed service also will adequately protect stations in the radiolocation service, including stations operating under footnote US 41. Coordination could be required in the event that the RR 2566 PFD thresholds are exceeded.

4.6 Sharing Between MSS/RDSS in the 2483.5-2500 MHz Band and the Fixed- and Broadcasting-Satellite Services Above 2500 MHz

Space-to-Earth links operating in the 2500-2655 MHz band are subject to the PFD limits of RR 2562, and the PFD of emissions falling in the 2483.5-2500 MHz band can be expected to be substantially lower than the RR 2562 levels. Thus, although the PFD allowed under RR 2562 is up to 5 dB greater than the RR 2566 PFD threshold for MSS/RDSS systems in the 2483.5-2500 MHz band, it can be expected that high carrier-to-power ratios will result from this adjacent band sharing. Moreover, in order to accommodate MSS (space-to-Earth) systems in the 2500-2520 MHz band at WARC-92, representatives of the Arabsat and Insat organizations that operate space-to-Earth links above 2500 MHz agreed to restrict their usage of the 2500-2520 MHz band. Thus, adjacent band interference from downlinks operating above 2500 MHz is expected to be at acceptable levels.

4.7 Sharing with MMDS/ITFS

The ITFS/MMDS services use twenty-eight 6-MHz channels in the 2500-2686 MHz band. The lowest channel, A1, is contiguous to the MSS downlink band and the next adjacent channel, B1, which occupies the channel extending from 2506 to 2512 MHz. Transmissions are usually similar to those of broadcast television. These transmissions may be changed from NTSC to digital in the near future. Signals are typically transmitted in narrow horizontal omnidirectional or cardioid patterns with maximum e.i.r.p.s of +33 dBW (for omni patterns) to +39 dBW (for directional patterns). Adjacent channels typically transmit using alternating horizontal and vertical linear polarizations. Co-channel and adjacent-channel stations are nominally separated by at least 50 miles with a technical showing required for shorter interference spacing. Details concerning the out-of-band filtering requirements for an ITFS channel are analyzed in IWG2-?.

They are permitted transmitter powers of 10-100 W and typically use 50 W. They use either omni or cardioid antennas with gains between 10 dB and 17 dB. Thus the e.i.r.p.s vary from 20 dBW to 37 dBW with 30 dBW being common. These e.i.r.p.s compete with similar e.i.r.p. levels in spacecraft at distances of around 1000 km. or more. Thus MMDS at one km. yields a PFD of -72 dBW/m^2-4kHz which is 70 dB higher than the maximum signal from any of the MSS downlinks. The current FCC requirements call for out-of-band emissions in these services to be restricted to -60 dB. This is inadequate. Restrictions on out of band emissions from the lowest channel should be limited to - 90 dB, assuming the channel is operating at 30 dBW. Adjustments should be made for the other channels and for higher or lower operating e.i.r.p.s. Even this requirement would leave a zone of something less than 1.0 km. around an ITFS transmitter in which a mobile terminal in the MSS will be interfered with seriously. Note that there are about 500 such stations in the U.S. and they are normally in metropolitan and suburban areas where operation of MSS terminals will be desirable. Interference from out-of- band emissions in the MSS to the ITFS will be negligible for the same reasons in reverse.

MMDS/ITFS/OFS operators can improve suppression out-of-band emissions to -90 db at 2498.75 Mhz as proposed by MSS WG2, by placing a sharp-cutoff waveguide filter and one or more directional isolators between transmitter and antenna, and placing a phase-delay-correction filter before the final amplifier of the transmitter. Because the sharp-cutoff filter will waste power, the operator likely will need to raise the output power of the final amplifier.

For today's stations, which emit NTSC signals, the cost per station for the improvement of suppression desired by the MSS operators will be from $10,000 to $30,000 or more.

For tomorrow's stations, which will emit compressed digital video signals, the cost per station likely will be more; the phase delay errors must be corrected far more carefully. Some stations will convert to digital within the next two years; most, we believe, within the decade.

The cost for the improvement of suppression can be reduced appreciably if the target frequency for -90 db suppression is shifted from 2498.75 Mhz to a slightly lower target frequency, such as 2497.7 Mhz (attenuation slope not over 22 db per Mhz, as already incorporated in Rules).

4.8 Impact of ISM Emissions in the 2483.5-2500 MHz Band

The 2400-2500 MHz band is allocated internationally by ITU footnote 752 and domestically by Part 18 of the Commission Rules for use by Industrial, Scientific and Medical (ISM) applications.

ISM uses include microwave ovens, door openers, high frequency lighting systems, industrial equipment and other low powered devices such as wireless communication devices. It is estimated that there are over 80 million microwave ovens currently in operation in the United States, with over 200 million microwave ovens worldwide. Industrial equipment, high efficiency lighting systems and wireless communications devices (e.g., R-LAN's) are also increasing the use of the ISM band in the United States and abroad.

The NTIA technical memorandum No. 92-154 gives the results of measurements that show emissions at 2480 MHz averaging about - 60 dBm (into a 2.5 dB receiver antenna) in a 300 kHz bandwidth at a distance of 3.0 meters. This was an average figure for four ovens. The radiation was jaggedly isotropic with, perhaps, a 10 dB higher amplitude toward the front of the oven. Presumably this was because of leakage around the doors. This can be converted to an equivalent of -141 dBW/m^2/4 kHz at a distance of 3.0 km. (assuming free space propagation), which is comparable to the received satellite signal. The situation is probably better at this distance because of the greater than free space loss to be expected. In addition most microwave ovens operate indoors and there will normally be some building blockage. Nonetheless, the NTIA measurements suggest that microwave ovens may cause interference to MSS mobile terminals operating in at least the lower part of the band within, say, a clear 1.0 km. of an operating oven. Fortunately most microwave ovens operate on a low duty cycle. It seems as if some FCC restriction on the band usage and leakage radiation for microwave ovens is very much in order. This is the subject of ET Docket # 91-313 which addresses harmonization of Part 18 of the FCC rules with international standards for ISM equipment. It may not be practical to do anything about the existing equipments, but they have finite lifetimes and most will be replaced within 10 years. The replacement equipment must be held to narrower bandwidths and higher standards of in band leakage.

Also of concern are microwave powered ultraviolet lamps which are in increasing industrial use. They typically use 24 kW banks of lamps and radiate, according to the rough calculations of the Fusion Systems Corp, about 35 W. Some published spectra show that they occupy the entire 2400-2500 MHz band, being perhaps 20 dB down at the edges. If the IWG2 assumes that they occupy about 50 MHz uniformly, and that the propagation is with the fourth power of the distance, we get about a half kilometer zone in which the ISM interference will be equal to the satellite signal. Again, it seems that stringent restrictions on the occupied bandwidth for these new industrial systems, along with limits on the leakage radiation, must be instituted by the FCC for new equipment.

4.8.1 ISM Emitters Effect on Noise in the 2483.5-2500 MHz Band

NTIA conducted tests in 1991 to determine the feasibility of accommodating other satellite radio services in the 2300-2450 MHz band. These tests also included measurements up to 2600 MHz.

The measurements included composite emissions at Boulder, Colorado from mountain sites overlooking the city. The population of Boulder is approximately 90,000 people. The purpose of these measurements was to estimate the equivalent EIRP of the ISM environment in Boulder. The aggregate EIRP from the distributed emitters was calculated by collecting the total power, using peak hold of the oscilloscope, from the distributed emitters and determining the power of a single emitter that would equal the power of the distributed emitters. The EIRP from the closest concentration of significant sources resulted in a value of between 29 and 30 dBm at 2450 MHz. These numbers correspond to between 24 and 25 dBm at 2483.5-2500 M Hz. The NTIA report then proceeded to determine that a maximum peak EIRP of 1 Watt appeared to characterize the ISM environment in Boulder. It further assumed that since the aggregate emissions appeared noise-like, a mean squared signal level would probably be 12 dB below the maximum EIRP. Extrapolating the NTIA data to determine the noise from ISM emitters in the band 2483.5-2500 MHz and adding an extra 5 dB of margin still results in a mean EIRP of between -17 and -18 dBW.

The equivalent interference signal power in the 2483.5-2500 MHz band can be determined as follows:

IPFD = EIRP(mean) - A - R

where:

IPFD = Estimated average power flux density of interfering signal

EIRP(mean) = Mean EIRP from measurement data

A = Area seen by the antenna (assumed to be about 49 square kilometers or 76.9 dB)

R = Ratio of 30 kHz to 4 kHz = 8.8 dB

IPFD = -17 - 76.9 - 8.8 = -102.7 dBW/m^2-4kHz.

The equivalent average interfering power spectral density (I_o) can be calculated as follows:

I_o = IPFD - G - S

where:

G = Gain of a 1 square meter antenna at 2.5 GHz (29.4 dB)

S = 10 Log (4kHz) = 36.0 dB

I_o = -102.7 - 29.4 - 36.0 = -168.1 dBW/Hz

Assuming a typical MSS receiver has a noise temperature of 250 degrees Kelvin, the noise floor of the receiver (N_o) would be -204.6 dBW/Hz.

Thus, the average interference power from ISM devices compared to noise is:

$I_o - N_o = -168.1 + 204.6 = 36.5$ dB.

This amount of ambient interference is significantly above the thermal noise floor of a typical MSS receiver in the 2483.5-2500 MHz band. Thus, this interference could reduce MSS capacity in urban areas. A study other than the NTIA was made (Geostar-1983) that suggest a less serious problem, at least for the proposed Geostar service at that time and when there were only 10 million microwave ovens rather than the 80 million existing today. The Geostar study was based on the probability that the Geostar RDSS burst interval would occur within the on-off timing cycle (80%) of the magnetron in a single microwave oven. Therefore, this analysis is not applicable to the continuous wave MSS in the aggregate microwave environment.

The IWG2 looks forward to further studies and analysis directed toward the MSS.

4.8.2 Possible Methods of Mitigating ISM Interference

There are several possible methods of mitigating ISM interference in the band. None of these methods, however, offers a complete solution to the problem.

Suppression of ISM emissions does not appear to be a likely solution in the short term, given the extensive use of the band for ISM applications. In the long term the FCC could consider tightening its regulations for occupied bandwidth and leakage.

The bursty nature of microwave oven emissions offers a potential for pulse blankers to mitigate the effects of interfering signals. Such signal processing, however, has several drawbacks and limitations, including (i) reduced sensitivity of the MSS receivers, (ii) difficulties in processing out the relatively high ISM interference levels, and (iii) the fact that no one signal processing solution can eliminate the various interference sources.

Increasing the power per channel of the MSS downlink to overcome ISM interfering power would substantially reduce the overall system capacity of systems sharing on an interference basis, and is otherwise limited by the PFD coordination triggers for protecting fixed services in the band.

MSS systems could decide to avoid those areas with high ambient ISM noise. This might be accomplished by using dual mode user terminals which would operate in the terrestrial cellular mode in urban areas and in the MSS mode in remote unpopulated areas.

4.8.3 Sharing with the ISM

The measurements conducted by NTIA reveal that, in a cumulative environment there may be a significant ISM interference noise floor in populated areas. Any MSS user terminal operating in such areas may experience varying levels of cumulative interference exceeding the thermal noise of the receiver. The IWG2 notes that the Geostar study was conducted in 1983 when there were 10 million microwave ovens compared to 80 million microwave ovens today, which produced some data that are different from the NTIA study.

This problem is likely to increase as more and more ISM devices enter the marketplace. Also the types of interference will become more diverse as different types of uses become prevalent.

There do not appear to be any adequate solutions to overcome ISM interference other than for MSS systems to avoid serving those areas with high ISM use (e.g., most urban areas).

Accordingly, MSS downlink transmissions in the 2483.5-2500 MHz band may be limited to sparsely populated areas. Even downlinks in these sparsely populated areas may experience interference varying by location and time.

5.0 Potential Sharing Solutions

5.1 Proposed Uplink Sharing Solutions

MSS system operators should be able to avoid L-band uplink interference to their uplinks by employing protection zones around existing fixed services locations. In addition, some MSS applicants will be able to avoid interference by using narrow band transmissions and alternative frequencies in coverage areas where other services are operating in foreign countries.

MSS operators should be able to coordinate MSS uplinks with foreign administrations by agreeing to accept a protection zone sufficient to protect an operating point-to-point Fixed Service. MSS receivers should be able to obtain a position signal from the satellite to avoid transmissions in these protection zones. If the receiver is within the protection zone, potential interference could be avoided by either ceasing transmission, or by operating in a frequency not used by the Fixed Service operator.

5.2 Proposed Downlink Sharing Solutions

Proposed MSS systems operating downlinks in the L-band should be able to avoid potential interference into the few systems operating in other services by using narrow band transmissions and different frequencies in coverage areas where such services are being used by foreign administrations. MSS systems can also rely upon the new international notification and coordination procedures adopted at WARC-92 to identify and resolve particular sharing and interference concerns of other administrations.

5.2.1 International Coordination Under Resolution 46

At WARC-92, an interim mechanism was established for notifying and coordinating LEO satellite systems with other administrations. These procedures are set forth in ITU Resolution 46, and closely mirror the existing rules for geostationary satellite systems. ITU Fn 731Y specifically applies these procedures to the MSS downlink:

> The use of the band 1613.8-1626.5 MHz by the mobile satellite service (space-to-Earth) is subject to the application of the coordination and notification procedures set forth in Resolution 46.

Under these procedures coordination with other administrations will be accomplished by the publication of Appendix 3 materials, notification from other administrations interested in pursuing coordination, the exchange of information between administrations, and the development of a plan to avoid interference and to share use of the band.

5.2.1.1 Coordination with Systems in the Fixed Service

Coordination with systems operating in the fixed service could be accomplished by a number of means, depending upon the number of systems in operation, the frequencies they use, and where they are located. For example, in light of the relatively large fixed service allocation (over 100 MHz), it may be possible to move these systems outside the affected band (less than 13 MHz). Interference could also be avoided through frequency agility in the MSS downlink transmissions by selecting frequencies in certain spot beams not expected to interfere with the fixed service system. It may also be possible to avoid specific geographic locations by controlling the downlink spot beam coverage.

5.2.1.2 Coordination with RDSS Systems

Future RDSS systems could be coordinated with MSS downlinks in the same manner that Motorola's IRIDIUM™ system was shown to share with Geostar's planned system. See JIWP 6A "Sharing between LEO and GEO systems in the RDSS, RAS, RNS and APC services in the vicinity of 1.6 GHz" (March, 1991).

5.2.1.3 Coordination with Swedish Radar

Motorola reported that as part of the technical discussions during WARC-92, compatibility between IRIDIUM™ system uplink and downlink MSS transmissions and the Swedish radar system was discussed by members of the U.S. and Swedish delegations. Members of both delegations concluded that the IRIDIUM™ system would not interfere with this radar system. It can be expected that further discussions will take place as a result of the international coordination process.

5.2.1.4 Coordination with Foreign Military Systems

Seven of the eight NATO European countries using the 1610-1626.5 MHz band for military communications have recently indicated that they will withdraw from use of this band before MSS operations commence. The German government is the only holdout; however, U.S. Army in Europe intends to vacate the band by October 1, 1993. If necessary, MSS systems would coordinate their downlink transmissions in accordance with ITU Resolution 46. The same techniques for sharing with other fixed services could be applied to military systems as well.

6.0 List of Participants

W. L. Pritchard - Chairman (LQSS)
R.E. Weiblin - CELSAT
L. Taylor - LQSS
Tom Sullivan - AMSC
John Knudsen - MOTOROLA
Harry Ng - FCC
Alfred Mamlet - MOTOROLA
Philip Malet - MOTOROLA
Charles Windett - LQSS
Raul Rodriguez - TRW
Steve Baruch - TRW

7.0 Meeting Dates - IWG2C Meeting Schedule

March 10, 1993 - Room 7315, FCC
March 18, 1993 - Room 856, FCC
March 19, 1993 - Room 7315, FCC
March 22, 1993 - Steptoe & Johnson
March 24, 1993 - Room 856, FCC

See also Addendum of Loral Qualcomm Satellite Services, Inc. on Sharing with ISM.

Addendum to Report of Drafting Group 2C:

Sharing with Services other than ARNS and RAS (April 6, 1993)

Submitted by: Loral Qualcomm Satellite Services, Inc.

Supported by: TRW Inc., Ellipsat Corporation and Constellation Communications, Inc.

The Drafting Group 2C Report of IWG-2 contains language in Section 4.8 which suggests that MSS downlink transmissions in the 2483.5-2500 MHz band may not be feasible in urban areas and may experience interference even in sparsely populated areas. LQSS acknowledges that ISM interference exists, but does not agree with the conclusion that it represents a significant problem to MSS and that operation in only sparsely populated areas may be possible.

First, it must be noted that the statements in Section 4.8 are based upon an NTIA study, which was concerned with use of the 2483.5-2500 MHz band for MSS uplinks, not MSS downlinks. Therefore, the NTIA results and conclusions may not be directly applicable to MSS downlink operations.

Second, the measurements conducted by NTIA indicate that there may be a cumulative environment ISM interference in urban areas. However, due to the limited testing and the configuration of the test, with respect to operation of MSS systems, the study cannot be deemed conclusive. MSS user terminals operating in such areas may experience varying levels of cumulative interference which may under certain circumstances exceed the thermal noise of the receiver.

Moreover, there are several mitigating effects which may reduce or eliminate the interference when operating in areas where there are concentrations of ISM devices. These mitigating effects are: shadowing and blocking, MES antenna patterns which reject ISM signals arriving most of the time at 0 degree elevation angles, and the ability of the CDMA link by link power control factor to overcome interference.

Shadowing & Blocking

The Globalstar MES user antenna pattern will provide significant rejection to interfering signals that are received in the horizontal direction. For those users operating in urban areas, the additional path loss from horizontal sources, such as microwave ovens, will be significant due to the walls of the building in which the ISM interfering source is housed, plus shadowing due to trees, blockage from buildings, etc. This blockage was not accounted for in the NTIA study. Vogel's analysis of building penetration path loss indicates that 16 dB is a typical value at 2.4 GHz. Urban path loss at ranges of 300 m or more can be expected to be on the order of 40 dB or more higher than free space loss depending upon distance from the radiating source.

MES Antenna Patterns

Significant rejection to interfering signals that are received in the horizontal direction can be achieved by the Globalstar MES user antenna pattern. For those users operating on hillsides overlooking urban areas, such as Boulder, CO, in the NTIA study, the MES antenna sidelobe rejection in the direction of potential interference is again significantly increased on the order of over 20 dB from the path of the desired Globalstar signal. Therefore, the expected interfering signal level at the MES receiver input is expected to be significantly reduced from the extrapolated interfering power flux density levels based upon the NTIA study.

CDMA Power Control

The Globalstar system incorporates CDMA which is an excellent spread spectrum technique for mitigating interfering signals. Should a Globalstar MES user operate in a high ISM interference area, the Globalstar system can increase the power in the satellite downlink S-Band signal to that particular user via the closed loop power control capability under the command of the Globalstar Gateway. Over 10 dB of forward path power control is available while still remaining within the constraints of the S-Band spectral power flux density limits. Since many users occupy the same RF channel, increasing the power to one user does not significantly increase the total power and PFD within the channel.

The Globalstar noise floor is equivalent to a PFD of about -140 $dBW/m^2/4$ kHz. This is approximately the average interference value in paragraph 4.8 of the Drafting Group C report based upon data at 2480 MHz from several microwave ovens in the NTIA report. In reviewing the NTIA data for these ovens, it appears that the average emission density over the 2483.5 to 2500 MHz band would be 20 dB lower or -162 $dBW/m^2/4$ kHz which is 22 dB below the Globalstar noise floor. The Globalstar system is well equipped to operate in this type of environment. As mentioned previously the Globalstar CDMA technique is well suited to counter not only interference from other MSS satellites, but also interference from the ISM band.

Interfering Power Flux Density Calculation

Based upon these mitigating factors, an MES user located in an urban area and 300 m from a signal microwave oven could expect an interfering power flux density (IPFD) of:

IPFD = PFD at 3 km + D - PL - UPLF

where PFD at 3 km equals -141 $dBW/m^2/4$ kHz

D = free space loss reduction due to decreased distance or 20 dB
PL = building penetration loss of 16 dB
UPIF = urban path loss factor of at lest 40 dB.

IPFD = -141 + 20 - 16 - 40 = -177 $dBW/m^2/4$ kHz

This is 37 dB below the Globalstar noise floor. Even with many microwave ovens operating, this should not present a problem in urban areas.

For the case of an MES user operating on a hillside near an urban area, the expected interfering flux density of nominally -103 $dBW/m^2/4$ kHz (as mentioned in paragraph 4.8.1) can be expected to be overcome by at least 20 dB of antenna rejection. The operator can improve this ratio by optimizing the orientation of the user handset. The Globalstar power control will also allow for at least 10 dB of additional downlink user power to overcome the interference. Nominally 12 dB of propagation loss due to foliage can be expected. Therefore, the composite interference is expected to be less than the Globalstar noise floor which is easily accommodated by the CDMA.

Conclusions on Sharing with the ISM

MES user terminals may operate in rural areas and thereby not be affected by cumulative ISM interference. For the occasional time that the MES terminal is located near a microwave oven when it is operating, the location of the user with respect to the ISM device is important. The input signal, in this case, to the MES will be mitigated by the MES antenna pattern and shadowing and blocking to about 20 db or more depending on the distance from the radiating source. In any case, should the interference be over the threshold both the power control and the path diversity combining gain will be used to mitigate the interference.

MES user terminals operating in suburban and urban areas and may experience some effect of cumulative interference. Since the shadowing and blocking of near zero elevation angle into the MES antenna is severe, and since the antenna pattern will reject horizontal interference, it is not expected to produce meaningful interference. MES user terminals operating on mountain areas overlooking urban areas, such as Boulder, Colorado, the MES antenna rejection of potential interference is also significantly increased over the desired Globalstar signal.

To the extent that there may be any interference from ISM there is also potential for dual mode operation using terrestrial cellular systems.

The potential interference from ISM devices, as more of these devices are deployed may increase. Further studies on levels of emissions under various conditions should be conducted in order to determine if additional measures of protection for the MSS systems are required.

An Alternate Analysis Based on NTIA Study

A somewhat different analysis, also based on the NTIA study, can lead to the conclusion that ISM will not be a problem in the MSS. We start with an average out-of-band emission figure of -60 dBm (4 ovens in Fig 3.1 of study averaged at 2480 MHz), measured at a distance of 3.0 m, in a 300 kHz bandwidth, and with a test antenna gain of 2.5 dBi. The flux density given by such a measurement is translatable into our terms, namely dBW/m^2-4 kHz by the equation

$$\phi = C - G_r + G_{1m2} - 10\ \text{Log}\ (300/4)$$

$$\phi = -60-30-2.5+29.25-18.75$$

$$\phi = -82\ \text{dBW/m}^2\text{-4 kHz}$$

At a distance of 300 m this translates, assuming free space propagation, into -122 dBW/m^2 -4kHz and at 3 km into a value of -142 dBW/m^2 -4 kHz.

In the reception of signals by an MES there are many factors that will serve to reduce this level of interference. A good MES antenna will be designed to have substantial rejection for horizontally propagated signals since it is designed to look upward at high elevation angles. This side lobe rejection can be the order of -20 dB in some cases and probably will average at least -10 dB. Building blockage (PL) can account for another 16 dB (according to Vogel) and urban path losses can be significantly in excess of the free space values (UPLF). This factor should be at least 40 dB. Under these circumstances the interference flux density is given by

$$\phi = \phi\ \text{(free space)} - PL - UPLF$$

$$\phi = -122-16-40$$

$$\phi = -178\ \text{dBW/m}^2\ \text{-4 kHz}$$

This is well below the noise floor for any MES receiver operating at the prescribed flux density of -142 dBW/m^2 -4 kHz. Even allowing for interference from a number of ovens operating simultaneously there should be no trouble.

ANNEX 3

MSSAC-43.10(Rev. 1)
April 6, 1993

REPORT OF WORKING GROUP 3 TO THE MSS ABOVE 1 GHZ NEGOTIATED RULEMAKING COMMITTEE

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(Note: All section numbers begin with 4 or 5. Section numbering system parallels that of the Report of the MSS Above 1 GHz Negotiated Rulemaking Working Group.)

4.1 Feeder Link Requirements, General Geostationary/Non-Geostationary Sharing Situation, and International Coordination Obligations

As specified in the Work Program for the MSS Above 1 GHz Negotiated Rulemaking Working Group (MSSAC-4 (Rev. 1)), Working Group 3 examined the feeder link requirements of the proponents of satellite systems that would provide MSS and RDSS services in the 1610-1626.5 MHz and 2483.5-2500 MHz bands. The Working Group's efforts included an attempt both to identify available frequencies and to show how the new feeder link operations could share the identified frequencies with existing and future users of the subject bands.

Technical and regulatory issues affecting both MSS/RDSS system feeder link operations and the proposal of one applicant to utilize frequencies in the 23 GHz band for inter-satellite link operations were explored, and the findings are presented below. In addition, Working Group 3 addressed the question of how to implement in the Commission's rules the provisions of International Telecommunication Union ("ITU") Radio Regulation No. 2613 ("RR 2613"), as this regulation applies to non-geostationary systems that intend to use the fixed-satellite service ("FSS") frequency allocations for their feeder link operations. Included in this examination was a generalized overview of the international coordination obligations that must be met by non-geostationary MSS system operators with respect to the FSS, and a detailed analysis of the obligations imposed upon non-geostationary space station operators by RR 2613 with respect to geostationary FSS space systems. Working Group 3 also identified a number of factors relevant to frequency sharing between non-geostationary MSS system feeder links and geostationary satellite system operations that apply irrespective of the frequency band involved.

4.1.1 System Requirements

The preferred frequency bands identified for feeder link operations by the applicants and potential applicants (see IWG3-2 (Rev. 2) and IWG3-20) are depicted in Table 4.1.1 below.

TABLE 4.1.1

APPLICANT	REQUIRED BANDWIDTH IN EACH DIRECTION*	PREFERRED FEEDER LINK BANDS (IN GHz) EARTH-SPACE	SPACE-EARTH
AMSC	TBD	14.0-14.5	11.7-12.2
CELSAT	150 MHz	29.825-29.975	20.025-20.175
CONSTELLATION (ARIES)	66 MHz**	6.5250-6.5910	5.150-5.216
ELLIPSAT (ELLIPSO)	66 MHz**	6.452-6.725	5.150-5.216
LQSS (GLOBALSTAR)	66 MHz**	6.4840-6.5415	5.1585-5.2160
MOTOROLA*** (IRIDIUM)	12 x 7.5 MHz	29.1-29.3	19.4-19.6
TRW (ODYSSEY)	101 MHz	29.5-30	19.7-20.2

* The greater the amount of spectrum that is available for the applicants' feeder link operations, the more channels of capacity their systems will be able to offer.

** Includes guardbands. Orthogonal polarizations will be used by each system within the 66 MHz bandwidth

*** Motorola has also requested 200 MHz in the band 23.18-23.38 GHz (8 x 25 MHz) for intersatellite link operations

The use of frequencies in the 5 GHz and 6 GHz band FSS allocations as feeder links is preferred by several of the applicants. The system designs of these applicants is such that the use of frequencies in this range for feeder links complements various other features of their system proposals, including the use of relatively low cost feeder link earth stations that would be resistant to propagation factors. C-Band feeder links allow these applicants to use well-established technology in a band where propagation factors do not result in significant cost impact on the system and where continuous service can be provided with a minimum of coordination domestically and internationally.

Other applicants have specified use of FSS allocations in the 20/30 GHz range. Among the reasons identified by these applicants for selection of Ka-Band feeder links are: the availability of spectrum in an existing FSS band; the relative ease of coordination between non-geostationary and geostationary FSS systems; the opportunity for greater feeder link bandwidth; the opportunity to utilize satellite antennas that will result in narrower beams that will reduce interference and make coordination easier; and the fact that most other users of the spectrum are fixed. Systems that operate in medium Earth orbit or that use intersatellite links are able to gain these benefits while covering the United States with fewer gateway stations.

4.1.2 Non-Geostationary MSS/RDSS Sharing Situation With Geostationary Satellite Networks

4.1.2.1 Introduction

In a fixed-satellite service ("FSS") environment consisting of both geostationary-satellite-orbit ("GSO") satellite networks and low-Earth-orbit ("LEO") satellite systems, there will be times when the alignment of earth stations and satellites produces a coupling that could cause interference to one or both systems. The points of maximum coupling occur when the earth station of one system is pointed at the satellite of the other system. The geometries that produce these maximum couplings are described below, and are depicted in Figure 4.1.2.1-1 (Cases 1-4).

Case 1 in Figure 4.1.2.1-1 depicts the potential for coupling on the uplink transmission that occurs when the LEO satellite is in the line from the LEO earth station to the GSO satellite.

Case 2 in Figure 4.1.2.1-1 depicts the potential for coupling on the uplink transmission that occurs when the LEO satellite is in the line from the GSO FSS earth station to the GSO satellite.

Case 3 in Figure 4.1.2.1-1 depicts the potential for coupling on the downlink transmission that occurs when the LEO satellite is in the line from the GSO satellite to the GSO earth station.

Case 4 in Figure 4.1.2.1-1 depicts the potential for coupling on the downlink transmission that occurs when the LEO satellite is in the line from the GSO FSS satellite to the LEO earth station.

Although this section of the report analyzes the probability that coupling will be observed, it does not analyze the potential interference situation that would result from such a coupling. (See Sections 4.2 and 4.4 below.) The Working Group notes that the significance of a coupling from an interference standpoint depends on a number of variables such as emission power levels, receiver sensitivities, antenna sizes and operational parameters, and the duration of the coupling.

4.1.2.2 The Effect of Different LEO Satellite Antenna Types

For LEO satellite antennas employing a horizon-to-horizon wide coverage pattern, the half-power-beamwidth ("HPBW") of the horizon-to-horizon beam is 110 degrees for an orbital altitude of 1407 km. This beamwidth produces a maximum area coverage on the surface of the Earth from the LEO constellation altitude.

For LEO satellites employing narrow beam antennas, a swath would be produced as the satellite moves across the sky. The width of the swath is the HPBW of the spacecraft antenna. Only those FSS earth stations located within the swath would experience mainbeam-to-mainbeam coupling. For example, if the HPBW is less than 87.8 degrees, GSO FSS earth stations located at latitudes equal to 50 degrees or higher would not be affected, since the smallest exocentric angle is 43.9 degrees. For earth stations located at latitudes lower than 30 degrees, the highest percentage of time for mainbeam-to-mainbeam coupling is reduced from 0.045% to 0.0067%.

A LEO satellite using a steerable spot beam illuminates a specific geographic area on Earth where the beam is aiming. Since the footprint of the spot beam remains stationary as the LEO satellite traverses the sky, only those GSO FSS earth stations within the footprint area would experience mainbeam-to-mainbeam coupling. The number of affected FSS earth stations would be less than for the narrow beam antenna cases.

4.1.2.3 Percentage of Time the LEO Satellite is in the GSO Earth Station Antenna Main Beam (Cases 2 and 3)

The coupling statistics are presented as a percentage of time that a LEO satellite traverses the mainbeam of an earth station antenna in a GSO FSS network. The result indicates that there will likely be times of beam couplings. Hence, there is a need to develop technical measures to facilitate frequency sharing between feeder links for LEO satellite systems and GSO FSS networks.

A study (IWG3-3) was conducted to calculate the percentage of time that a LEO satellite (at 1406 km altitude in a 48-satellite constellation) and the GSO satellite are within the mainbeam (e.g., HPBW) of the earth station antenna simultaneously. The result indicates that the percentage of time statistics for both one-degree and four-degree HPBW earth station antennas decrease as the earth station antenna elevation angle increases -- e.g., at an elevation angle of 10 degrees, the percentage of time varies between 0.018% and 0.048%; it decreases to about 0.0076% or less at high elevation angles for the one-degree HPBW antenna.

The time it takes for a LEO satellite to traverse the mainbeam of an FSS earth station antenna is also important. For an FSS earth station with a one-degree HPBW at a low elevation angle (e.g., about 10 degrees), the maximum transit time is about 15 seconds. The transit time decreases to about six seconds when the elevation angle is increased to 45 degrees.

Other parameters such as the number of LEO satellites, the number of orbital planes, the inclination angle, and the orbital altitude also influence the output result. However, for circular orbit constellations with low to moderate altitude, the conclusions are similar.

The study showed that for a 12-satellite medium Earth orbit constellation (16,740 km orbital radius), the non-geostationary satellite would be within two degrees of the bore-sight direction of an FSS earth station antenna 0.22% of the time. The time it would take a satellite in this constellation to traverse the four-degree cone is 3 minutes and 56 seconds.

4.1.2.4 Potential Interference into a GSO FSS Network

For a small percentage of time, a GSO FSS earth station, a LEO satellite, and a GSO satellite could align in a straight line (Figure 4.1.2.1-1, Case 3). This alignment produces a coupling between the LEO satellite antenna and the GSO FSS earth station antenna. Hence, there could be potential harmful interference from a LEO satellite downlink transmission into a GSO FSS receiving earth station if the two systems share the same frequency. The extent of any interference to the GSO system resulting from this coupling depends upon the gain of the LEO earth station antenna in the direction of the GSO earth station, which in turn is dependent upon the separation of the earth stations and the shape of the LEO satellite beam.

For the uplink case (Figure 4.1.2.1-1, Case 1), a LEO satellite feeder link transmitting earth station could also cause potentially harmful interference into the GSO FSS receiving space station, although the extent of any interference to the GSO system resulting from this coupling depends upon the gain of the LEO earth station antenna and the square of the ratio of the path links. This observation is based on the fact that the geometry is identical whether the earth station is part of the LEO satellite system or the GSO satellite network.

In addition to certain LEO satellite antenna designs, LEO feeder link site diversity and/or alternate gateways could be used to eliminate any uplink interference into the GSO satellite receiver. That is, another feeder link site could be used when the geometry of the active earth station, the LEO satellite, and the GSO satellite is such that interference could occur.

4.1.2.5 Potential Interference into a LEO Satellite System

For the uplink case (Figure 4.1.2.1-1, Case 2), a GSO earth station could transmit into the LEO satellite. The extent of any interference to the LEO system resulting from this coupling depends on the gain of the LEO satellite antenna in the direction of the GSO earth station, which in turn is dependent on the separation of the earth stations and the shape of the satellite beam. This potential problem could be minimized through LEO antenna design or employment of alternate satellites. However, large numbers of broadbeam GSO FSS earth terminals could create a problem.

For the downlink case (Figure 4.1.2.1-1, Case 4), the extent of any interference to the LEO system resulting from the coupling of the GSO satellite and the LEO earth station depends on the gain of the satellite antenna in the direction of the LEO earth station, which in turn is dependent on the separation of the earth stations and the shape of the GSO satellite beam. While small spot beams from the GSO satellite are required to reduce this coupling, the potential problem posed by a GSO FSS satellite transmitting to an associated earth station can be minimized through the use of high gain antennas at the LEO system gateway and through the utilization of alternate satellites or gateways when this alignment occurs.

4.1.2.6 Multiple Earth Stations

The above analysis is for a single earth station in a LEO feeder link satellite system or a GSO FSS network. In a multiple earth station environment, a simultaneous occurrence of two or more earth station-LEO-GSO alignments is extremely small. Hence, the aggregate beam coupling statistics would be equal to the single earth station coupling statistics multiplied by the number of earth stations in the system within the co-coverage area.

4.1.2.7 Conclusion

Coupling between LEO satellites systems and GSO satellite networks is likely to occur, depending on the extent to which GSO satellite networks exist in the frequency bands to be shared. In this section of the report, Working Group 3 makes no determination on whether and when beam coupling will lead to an increased potential for harmful interference. It also does not discuss all possible alleviating mechanisms, such as whether the LEO system can be operated with a repeating ground track, thereby opening up the possibility of never interfering with some GSO orbit locations.

What the analysis shows is that the coupling time statistic is relatively short -- on the order of a few hundredths of one percent. Yet, the transit time for the LEO satellite to traverse the mainbeam of a GSO earth station antenna is relatively long -- on the order of seconds to tens of seconds. Furthermore, the coupling statistics increase proportionately with the number of LEO satellite feeder link earth stations.

Several operational and LEO satellite antenna designs could either eliminate beam coupling or reduce the coupling time statistics to as small as necessary. These include:

-- LEO satellite feeder uplink site diversity;

-- Narrow beam LEO satellite antennas;

-- Steerable spot beam LEO satellite antennas; and

-- Relatively large LEO and GSO earth station antenna size.

Accordingly, in order to have GSO-FSS and LEO satellite feeder links sharing the same frequency bands, there is a need to establish the extent, if any, to which coupling between GSO FSS and LEO systems would inhibit the operation of either system. If the interference situation warrants, it will be necessary to establish a set of balanced sharing principles and interference criteria, based in whole or in part on the options identified above, that would permit successful co-channel operation of both LEO and GSO systems.

Sections 4.2, 4.4.2, and 4.4.3 describe how the techniques discussed here (and others as well) can be used to establish coordinated LEO/GSO sharing arrangements that will avoid mutual harmful interference. If the sharing principles to reduce beam coupling prove too restrictive, it may be necessary to explore other options -- such as the possibility of establishing geographic exclusion zones where GSO-FSS and/or LEO feeder link operations would be prohibited, or the use of dedicated frequency allocations for LEO satellite feeder link use.

4.1.3 International Process Regarding Non-Geostationary Satellite Operations in Bands Shared With Geostationary FSS Systems

4.1.3.1 Overview

The International Frequency Registration Board ("IFRB") of the ITU is charged with interpreting and managing the implementation of the ITU Radio Regulations subsequent to radio conferences. This is done through the issuance of Rules of Procedure. For example, in IFRB Circular Letter 921, 11 December 1992, the IFRB issued a Rule of Procedure on the Application of Provisions of Resolution No. 46 (which provides interim international coordination procedures for systems including the non-geostationary MSS/RDSS systems proposed for the 1610-1626.5 MHz and 2483.5-2500 MHz bands). The rule of procedure sets forth how the IFRB would apply Resolution 46.

There is no rule of procedure for RR 2613. Up to now, the IFRB has had limited occasion to apply this Radio Regulation. Now, however, as a consequence of the potential extensive use of FSS frequencies for feeder links for non-geostationary satellites, the IFRB staff has begun examining this issue. In addition, several cognizant groups of the International Radio Consultative Working Group ("CCIR") are also becoming quite interested, and are attempting to develop applicable criteria. See Document No. MSSAC/IWG3-11 (which consists of a set of questions presently adopted by Working Party 4A, and acknowledged by Working Party 8D).

Pending the development of such criteria as may be applicable, the IFRB has encouraged that Administrations indicate when submitting coordination information in accordance with Article 11 of the Radio Regulations that a statement be included about the intent to address RR 2613. The IFRB, however, appears to be of the view that Administrations need to be mindful of the existence of the RR 2613 obligations during their coordinations. This view is expressed in a 7 December 1992 letter from the IFRB to the Commission. See Attachment to Document No. MSSAC/IWG3-22 (Rev. 1).

As indicated in Section 4.1.3.2 of this Report, RR 2613 applies only to the geostationary FSS. Resolution 46, however, mandates that coordination take place among non-geostationary satellite systems, and between non-geostationary and geostationary satellite systems when operating in the bands in which MSS services are provided (identified in Rule of Procedure H-52). The CCIR questions and liaison statement between Working Party 8D and Working Party 4A (Document No. MSSAC/IWG3-11) suggest a linkage between MSS and FSS frequency use. Whether mandated or not, it is clear that some sort of coordination will need to take place between non-geostationary systems and geostationary FSS systems in order to ensure that unacceptable interference does not take place. What this actually means will depend on the particular systems concerned.

4.1.3.2 International Application and Interpretation of Radio Regulation 2613

As modified at the 1992 World Administrative Radio Conference, International Radio Regulation 2613 provides as follows:

> "Non-geostationary space stations shall cease or reduce to a negligible level their emissions, and their associated earth stations shall not transmit to them, whenever there is insufficient angular separation between non-geostationary satellites and geostationary satellites resulting in unacceptable interference1/ to geostationary satellite space systems in the fixed-satellite service operating in accordance with these Regulations.
>
> 1/ The level of accepted interference shall be fixed by agreement between the administrations concerned, using the relevant CCIR Recommendations as a guide."

Final Acts of WARC-92, Radio Reg. 2613.

In analyzing RR 2613 with regard to the services under consideration by the MSS Above 1 GHz Negotiated Rulemaking Working Group, several observations must be made at the outset. First of all, as explained below, RR 2613 is not applicable to non-geostationary and geostationary space systems within a single administration; it only applies as between non-geostationary satellites of one administration and geostationary FSS space systems of one or more other administrations. Thus, the RR 2613 has no applicability as between systems authorized by the Commission.

Next, RR 2613 clearly does not relegate non-geostationary space stations (or their associated earth stations) to secondary status with respect to geostationary FSS operations in shared bands. Under the Radio Regulations and the Commission's own rules, stations in a "secondary" service shall not cause "harmful" interference to primary or permitted service stations that are using the subject frequency bands in a manner consistent with the Radio Regulations. See RR 420-423; 47 C.F.R. §§2.104(d)(4) and 2.105(c)(3). In RR 2613, the "obligation" of non-geostationary space stations to reduce their emissions to a negligible level (or cease them altogether) does not arise at all unless there is "insufficient angular separation" between non-geostationary and geostationary satellites that causes "unacceptable interference" to geostationary FSS space systems. The RR 2613 obligation is not affected by a station's "primary" or "secondary" status.

It is also clear, by virtue of the ITU's selection of the term "unacceptable interference" as a condition that must exist before the RR 2613 obligations can come into play, that the requirement cannot be applied without prior coordination or at least communication between affected systems of different administrations. The term "unacceptable interference" lacks a formal definition in the ITU Radio Regulations. However, the term "accepted interference" is defined in RR 162 as "*[i]nterference* at a higher level than that defined as ***permissible interference*** and which has been agreed upon between two or more administrations without prejudice to other administrations." It also appears that the term "unacceptable interference" is used by the ITU to signify a level of interference that is in excess of "accepted interference." See Note 1 to RR 2613 (RR 2613.1/2614.1). See also RR 2619 & n.3 (RR 2619.1). It thus becomes the case that a finding of "unacceptable interference" -- i.e., a level of interference that exceeds a level that had previously been agreed upon between two or more administrations -- can only be made if there has been some initial agreement on acceptable interference levels between two or more administrations.

Finally, RR 2613 is limited in application to geostationary satellites and associated earth stations that provide FSS service. Only space systems comprised of geostationary satellites that provide FSS services can invoke RR 2613, because RR 2613 applies only to geostationary space systems "in the fixed-satellite service operating in accordance with these Regulations."

4.1.4 International Application of RR 2613

With regard to international application of RR 2613, the Working Group recommends that the United States determine its obligations under RR 2613 in the following manner. Three conditions must be met before a non-geostationary system would be required to cease or reduce transmissions in order to protect a geostationary system. First, the administrations of the systems involved must engage in bi-lateral or multi-lateral discussions and reach agreement as to a level of "accepted interference" (see RR 162). Second, after the systems are in operation, the non-geostationary system must exceed the level of interference agreed to. Third, the interference in excess of the agreed level must be caused by the failure of the non-geostationary system to maintain sufficient angular separation between the satellites of the two systems. If any of these three conditions is not met, RR 2613 cannot be invoked to affect the operations of any non-geostationary satellites.

This interpretation of RR 2613 will provide an existing non-geostationary satellite system that operates in FSS bands with a necessary measure of protection against a demand from a future geostationary FSS system that they cease or reduce transmissions. A geostationary FSS system operator would be required to coordinate with existing non-geostationary systems to arrive at a level of "accepted" interference before any demand to cease or reduce transmissions resulting from "unacceptable" interference can be made -- a requirement that does not otherwise exist under the ITU Radio Regulations. The Working Group recommends that the United States seek in appropriate international radio fora the adoption of procedures to afford balanced protection for a non-geostationary system from future geostationary systems. At the least the United States should seek to have the above interpretation of RR 2613 applied internationally.

No modifications to the Commission's rules would be needed with regard to international application of RR 2613. Section 25.111 requires applicants to provide the Commission with all information necessary to complete the IFRB processes, and subjects station licenses to additional terms and conditions pending the completion of applicable discussions with other Administrations. See 47 C.F.R. § 25.111(b).

4.1.5 Domestic Regulatory Approach to RR 2613

On the basis of the foregoing, RR 2613 does not apply to the case of a non-geostationary and a geostationary FSS system that are licensed by a single Administration. However, the question remains of how to address shared frequency use by a non-geostationary and a geostationary FSS system that are licensed by the Commission.

For purposes of the Commission's regulations, all that should be included for operators of non-geostationary and geostationary FSS systems licensed or to be licensed by the Commission is a requirement in Part 25 of the FCC's rules that affected operators coordinate their use of the shared bands. This requirement should take the form of a regulation in Part 25 of the FCC's rules that requires coordination between affected U.S. systems.

This domestic coordination would occur regardless of whether the geostationary FSS or non-geostationary system is the first to be operational. The Working Group recognized that significant obstacles to coordination might exist in the case of non-geostationary systems that propose to operate feeder links in frequency bands that are heavily populated by GSO-FSS systems. Conversely, coordination would be significantly easier for non-geostationary systems that propose to operate feeder links in frequency bands that are not heavily populated by GSO-FSS systems.

Rules to address this situation are presented in Section 5.

4.2 Feederlinks in the 5/6 GHz Bands

Three of the LEO MSS systems above 1 GHz applicants have proposed the use of the 5150-5216 MHz band for feeder links operating in the space-to-Earth direction. Loral Qualcomm Satellite Services, Inc. and Constellation Communications, in their applications filed June 3, 1991, applied for use of the 5150-5216 MHz band for feeder links in the space-to-Earth direction. Ellipsat, during this NRM, has indicated its plans to amend its application to use the band 5150-5216 MHz for feeder links in the space-to-Earth direction.

Thus, the currently proposed feeder links of these three applicants are as follows:

MSS Applicant	Earth-to-space	Space-to-Earth
Globalstar	6484 - 6541 MHz	5150-5216 MHz
Constellation	6525 - 6591 MHz	5150-5216 MHz
Ellipsat	6452 - 6725 MHz	5150-5216 MHz

4.2.1 6 GHz Uplinks

The feeder links proposed in the Earth-to-space direction (6425-6725 MHz) are available for use as feeder links because they are allocated to the fixed-satellite service. No questions were raised during the NRM concerning the ability of the MSS/RDSS systems to share these bands with other fixed-satellite operations. It is noted that there are no United States FSS systems operating in these bands. However, the PACSTAR system, which proposes to provide service in the Pacific Ocean Region, has notified two satellites, and advance published two additional satellites, which would use portions of this band.

4.2.2 5 GHz Downlinks

Section 25.202 (a)(1) of the Commission's rules identifies feederlink bands for RDSS. Establishment of this rule was based on the requirement for GSO RDSS systems. In proposing LEO RDSS/MSS systems, several applicants assumed that these RDSS feederlink bands would also be available for their systems. Following the filing of these applications on June 3, 1991, these applicants sought U.S. support for adding MSS to Footnote 797A. However, the U.S. decided not to seek this change at WARC-92. In the applicants' opinion, this revision would have been consistent with the various United States proposals to add mobile-satellite service on a co-primary basis to the bands 1610-1626.5 MHz to 2483.5-2500 MHz.

The Commission, in its NPRM proposing the allocation of the 1610-1626.5 MHz and 2483.5-2500 MHz bands for MSS, stated that it is "not proposing to authorize use of the 5150-5216 MHz band for feeder link operations for MSS LEO or for mixed MSS LEO/RDSS systems because such use would not be compatible with the aeronautical radio navigation uses currently operating in this band." The Commission went on to state that "with MSS operations the numbers of earth stations is increasing and we anticipate problems with potential interference to the radionavigation service." Notice of Proposed Rulemaking, para. 26.